Philosophical Transactions

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PHILOSOPHICAL TRANSACTIONS.

May 10. 1669.

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Inſtructions

Concerning the Vſe of Pendulum-Watches, *for finding the* Longitude *at Sea.*

W*Hereas 'tis generally eſteemed that there is no Practiſe for the* Finding of the Longitude *at ſea comparable to that of thoſe Watches, which inſtead of a* Ballance-wheele *are regulated by a* Pendulum, *as* now *they are brought to great perfection, and made to meaſure time very equally; and many perhaps here as* *well as elſewhere being not well verſed in the ordering and managing of that Inſtrument: We thought, it might be no un-acceptable ſervice, to make known ſuch Directions, as may teach the Uſe thereof at Sea. Which we ſhall doe by now giveing you our Tranſlation of thoſe inſtructions, which ſome yeares ſince were made publick by the Worthy M.* Chriſtian Hugens *of* Zulechem, *in the* Belgick *Tongue, as they have been ſince altered or rather* enlarged *by two other Eminent Members of the R.* Society. *And they are theſe;*

1.

THoſe, that intend to make uſe of *Pendulum-watches* at Sea, muſt have two of them at leaſt; that, if one of them ſhould by mishap or neglect come to ſtop, or (being by length of time become foul) need to be made clean, there may likely always remaine one in motion.

2.

The Perſon, to whom the Care of theſe Watches ſhall be committed, is to informe himſelf from the Watch-maker or ſome other, ſo as to underſtand the inward parts of the Watches, the manner of winding them up, and how to ſet the *Indexes*, or *Hands* having the hours, minutes and ſeconds, *&c.*

3.

The Watches on Ship-board are to be hung in a cloſe place, where they may be freeſt from moiſture or duſt, and out of danger of being diſorder'd by knocking or touching.

4.

Before the Watches be brought on ſhip-board, 'tis convenient, they be adjuſted to a *middle* or *mean* day (of which more in the next *Section*:) the uſe of them being then moſt eaſy, it being little or no trouble to the Watchmakers, when they have one that is ſet Juſt, to ſet others accordingly: But yet, if time or conveniency ſo to doe ſhould happen to be wanting, they may notwithſtanding be uſed at Sea with the like certainty, provided you know, how much they goe too faſt or too ſlow in 24. hours, as is directed in the next Section.

5.

To reduce Watches to the right meaſure of dayes, or to know how much they goe too faſt or too ſlow in 24. hours.

Here take notice, that the *Sun* or the *Earth* paſſeth the 12. *Signes*, or makes an entire revolution in the *Eclíptick* in 365 days, 5 hours, 49 min. or there about, and that thoſe days, reckon'd from noon to noon, are of *different* lengths; as is known to all, that are verſ'd in *Aſtronomy*. Now between the longeſt and the ſhorteſt of thoſe days, a day may be taken of ſuch a length, as 365 ſuch days, 5. hours *&c.* (the ſame numbers as before) make up, or are equall to that revolution: And this is call'd the *Equal* or *Mean* day, according to which the Watches are to be ſet; and therefore the Hour or Minute ſhew'd by the *Watches*, though they be perfectly Iuſt and equal, muſt needs differ almoſt continually from thoſe that are ſhew'd by the *Sun*, or are reckon'd according to its Motion. But this Difference is regular, and is otherwiſe call'd the *Æquation*, and here you have a *Table*, that ſhows it.

	Januar.		*Februa.*		*Mar.*		*April.*		*Mai.*		*Jun.*	
	m.	*ſec.*	*m.*	*ſec.*	*m.*	*ſec.*	*m.*	*ſec.*	*m.*	*ſec.*	*m.*	*ſec.*
1	6	10	0	0	4	46	14	23	19	25	16	24
2	5	47	0	2	5	3	14	39	19	28	16	13
3	5	24	0	4	5	21	14	55	19	29	16	1
4	5	2	0	8	5	39	15	10	19	29	15	49
5	4	41	0	12	5	57	15	25	19	29	15	37
6	4	21	0	16	6	15	15	39	19	28	15	24
7	4	2	0	21	6	33	15	53	19	26	15	11
8	3	44	0	26	6	51	16	7	19	24	14	58
9	3	27	0	32	7	9	16	21	19	21	14	45
10	3	11	0	40	7	27	16	34	19	18	14	32
11	2	55	0	48	7	45	16	47	19	15	14	19
12	2	39	0	57	8	3	16	59	19	11	14	6
13	2	23	1	6	8	22	17	11	19	7	13	53
14	2	7	1	16	8	41	17	22	19	2	13	40
15	1	52	1	26	9	1	17	33	18	57	13	27
16	1	38	1	37	9	21	17	43	18	51	13	15
17	1	25	1	49	9	41	17	53	18	45	13	3
18	1	13	2	2	10	1	18	3	18	39	12	52
19	1	2	2	15	10	21	18	13	18	33	12	41
20	0	51	2	28	10	40	18	23	18	26	12	30
21	0	41	2	42	10	59	18	32	18	18	12	19
22	0	32	2	56	11	18	18	39	18	10	12	8
23	0	24	3	11	11	37	18	46	18	1	11	58
24	0	18	3	26	11	56	18	53	17	51	11	48
25	0	13	3	41	12	15	18	59	17	41	11	38
26	0	9	3	56	12	34	19	4	17	30	11	28
27	0	6	4	12	12	53	19	9	17	19	11	18
28	0	3	4	29	13	12	19	14	17	8	11	9
29	0	1			13	31	19	18	16	57	11	0
30	0	0			13	49	19	22	16	46	11	52
31	0	0			14	6			16	35		

	Jul.		*Aug.*		*Sept.*		*Oct.*		*Nov.*		*Dec.*	
	m.	*ſec.*	*m.*	*ſec.*	*m.*	*ſec.*	*m.*	*ſec.*	*m.*	*ſec.*	*m.*	*ſec.*
1	10	45	11	7	19	41	29	16	31	13	21	14
2	10	38	11	16	20	1	29	30	31	3	20	44
3	10	31	11	25	20	22	29	43	30	53	20	14
4	10	25	11	36	20	43	29	56	30	43	19	44
5	10	19	11	48	21	4	30	9	30	32	19	14
6	10	13	12	1	21	25	30	22	30	20	18	44
7	10	7	12	14	21	47	30	34	30	8	18	14
8	10	2	12	28	22	9	30	45	29	55	17	44
9	9	58	12	42	22	31	30	55	29	40	17	14
10	9	54	12	57	22	52	31	4	29	23	16	44
11	9	51	13	12	23	13	31	12	29	6	16	14
12	9	49	13	27	23	33	31	19	28	48	15	44
13	9	47	13	43	23	53	31	26	28	30	15	14
14	9	46	13	59	24	13	31	32	28	11	14	43
15	9	46	14	16	24	33	31	38	27	51	14	12
16	9	46	14	33	24	53	31	43	27	30	13	41
17	9	47	14	50	25	13	31	47	27	8	13	10
18	9	49	15	8	25	33	31	50	26	45	12	40
19	9	52	15	26	25	52	31	53	26	22	12	10
20	9	56	15	45	26	11	31	55	25	58	11	40
21	10	0	16	4	26	30	31	55	25	34	11	10
22	10	4	16	23	26	49	31	55	25	10	10	40
23	10	8	16	42	27	8	31	55	24	45	10	10
24	10	13	17	1	27	26	31	54	24	20	9	41
25	10	18	17	21	27	43	31	52	23	55	9	13
26	10	23	17	41	28	0	31	50	23	30	8	45
27	10	28	18	1	28	16	31	47	23	4	8	17
28	10	34	18	21	28	32	31	43	22	38	7	50
29	10	41	18	41	28	47	31	37	22	11	7	23
30	10	49	19	1	29	2	31	30	21	43	6	58
31	10	58	19	21			31	22			6	34

By the help of this *Table* you will always know, what a Clock it is by the Sun preciſely, and conſequently, whether the Watches have been ſet to the right meaſure of the *Mean* day, or no; uſing the *Table*, as follows.

When you firſt ſet your Watch by the Sun, you are to ſubduct from the time obſerved by the Sun, the Æquation adjoyned to that day of the Month in the Table, and to ſet the Watches to the remaining hours, minuts and ſeconds, that is, the Watches are to be ſet ſo much ſlower, than the time of the Sun, as(in the Table) is the Æquation of that day; ſo that the Æquation of the Day, added to the time of the Clock, is the true time by the Sun. And when after ſome days, you deſire to know by the Watch the time by the Sun, you are to add to the time, ſhew'd by the Watch, the Æquation of that day; and the Aggregate ſhall be the time by the Sun, if the Watch hath been perfectly well adjuſted after the meaſure of the *Mean* days; for the doing of which, this will be a Convenient way;

Draw a Meridian line upon a floor (the manner of doing which is ſufficiently known; and note, that the utmoſt exactneſs herein is not neceſſary:) and then hang two plummets, each by a ſmall thred or wire, directly over the ſaid Meridian, at the diſtance of ſome 2. foot or more one from the other, as the ſmalneſs of the thred will admit. When the middle of the Sun (the Eye being placed ſo, as to bring both the threds into one line) appears to be in the ſame line exactly (for the better and more ſecure diſcerning whereof, you muſt be furniſh't with a glaſs of a dark colour, or ſomewhat blackt with the ſmoak of a Candle,) you are then immediatly to ſet the Watch, not preciſely to the hour of 12. but by ſo much leſs, as is the Æquation of that day by the Table. E. g. If it were the 12 of *March*, the Æquation of that day being by the Table, 8 min. 3 ſec; theſe are to be ſubducted from 12. hours, and the remainder will be 11. hours, 51. min. 57. ſec; to which hours, minutes and ſeconds you are to ſet the *Index* of the Watch reſpectively: Then after ſome days you are to obſerve again in the ſame manner, and likewiſe to note the hour, min. and ſec. of the Watch; to which you are to add the

Æquation of theſe days, taken out of the Table; And if the Aggregate doe Iuſt make 12. hours, the Watch is ſet adjuſted to the right meaſure; but if it differ, you are to divide the minutes and ſeconds of that difference by the number of the days between both the Obſervations, to get the daily difference. Let us ſuppoſe, this ſecond Obſervation to have been made the 20. of *March*, viz. 8. days after the firſt, and finding, that the Middle of the Sun being ſeen in the Meridian in the ſame line

	h.	m.	ſec.
with the two threds, as before, the Watch points	11	51	7
The Æquation of the 20 of *March*, by the Table, is	0	10	40
Which being added to the time, ſhow'd by the Watch, gives	12	1	47

If this had been Iuſt 12 hours, the Watch would have been well adjuſted, but being 1. min. 47. ſec. more than 12, it hath gone ſo much too faſt in 8. days. And theſe 1 min. 47. ſec. that is, 107. ſec. being divided by 8, there comes 13⅜ ſec. for the difference of every 24. hours; which difference being known, if you want time, or have no mind to take the pains to adjuſt the Watch to its right meaſure (this being not neceſſary, ſince you may bring it thus on ſhip-board) note onely the daily difference, and regulate your ſelf accordingly, as hath been mention'd. But if you will adjuſt it better, you muſt remove the leſs weight of the Pendulum a little downwards, which will make it goe ſlower; and then you muſt begin to obſerve anew by the Sun, as before. If it had gone too ſlow, you muſt have remov'd the mention'd weight ſomewhat upwards. And this is of that importance in the finding out of *Longitudes*, that, if it be not obſerv'd, you may ſometimes in the ſpace of 3 months miſreckon 7. degrees and more (yet without any fault in the Watches;) which under the *Tropicks* will amout to above 400 Engliſh miles.

Having ſhew'd, How the Watches may be adjuſted at Land, or how their daily difference may be known; next ſhall follow, How the ſame may be done, when a Veſſel rides at anchor, it being hardly feſible when ſhe is under ſaile.

In the morning then, when the Sun is juſt half above the *Horizon*, note, what hour, min. and ſec. the Watch points at, if it be going; if not, ſet it a going, and put the *Indexes*, at what hour, min. and ſec. you pleaſe. Let them goe till Sun-ſet, and when the Body of the Sun is juſt half under the Horizon, ſee, what hour, min. and ſec. the *Indexes* of the Watch point at, and note them too; and reckon, how many houres *&c.* are Paſſ'd by the Watch between the one and the other: which is done by adding to the Evening-Obſervation the hours, *&c.* that the morning-Obſervation wanted of 12. or 24. in caſe the Hour-hand hath in the mean time paſſ'd that hour once or twice; otherwiſe the difference only gives the time. Then take the half of that number, and add it to the hours, *&c.* of the morning Obſervation, and you ſhall have the hours, *&c.* which the Watch did ſhow, when the Sun was in the *South*; whereunto add the Æquation in the Table belonging to that day, and note the ſumme. Then ſome days being paſſ'd (the more the better,) you are to doe Iuſt the ſame: And if the hour of this laſt day be the ſame, that was noted before, your Watch is well adjuſted; but if it be more or leſs, the difference divided by the number, elapſed between the two Obſervations, will give the daily difference. And if you will, you may let it reſt there, or otherwiſe, removing the leſſer weight of the Pendulum you may adjuſt it better.

	H.	m.	ſec.		H.	m.	ſec
E. g. Suppoſe *March* 11th in the Morning, when the Sun half appears above the Horizon, the Watch points at	5	30	10		0	10	3
In the Evening, when the Sun appears half ſet, at	5	20	6		11	59	59
To know by the Watch the time elaps'd between both, ſubduct the time of the riſing	5	30	10				
From	12	0	0				
Reſts	6	29	50				
Whereunto adding the time of the ſetting	5	20	6				
There comes for the time elapſed between them	11	49	56		11	49	56
Whereof the half is	5	54	58		5	54	58
Which added to the time of the Suns riſing	5	30	10		0	10	3
There comes the time of the Watch when the Sun was in the South	11	25	8	diff.	6	5	1
To which adding the Æquation of the 11th of *March*	0	7	45		0	7	45
The Summe is	11	32	53		6	12	46
Seven days after, *viz.* *March* 18, let the riſing of the Sun be obſerv'd, and the Watch point then at	5	19	4		11	58	57
And at his ſetting, let the Watch point at	5	25	2		0	4	55
To find the time elaps'd between them, ſubduct the time of the riſing,	5	19	4	Or.	11	58	51
From	12	0	0		24	0	0
Reſts	6	40	56		12	1	3
To which adde the time of the ſetting	5	25	2		0	4	55
And you'l find the time paſt between them	12	5	58		12	5	58
Whereof the half is	6	2	59		6	2	59
Which adde to the time of the riſing	5	19	4		11	58	57
And you have the time when the Sun was in the South	11	22	3		6	1	56
Whereunto adding the Æquation of *March* 18	0	10	1		0	10	1
The Summe is	11	32	4		6	11	57
Which Summe if it had agreed with the firſt, *viz.*	11	32	53		6	12	46

then had the watch been ſet to the right meaſure; but ſeeing the latter is leſs than the former, the difference being 49. ſec; the Watch hath by ſo much, in 7. days, gone too ſlow; which 49*Sec.* divided by the number of days, you have 7*Sec.* for the daily difference; and by ſo much the Watch goes too ſlow in 24. hours.

You may alſo, inſtead of the Suns riſing and ſetting, take two equall Altitudes of the Sun, before and after Noon, and having noted the time given by the Watches at the time of both the Obſervations, proceed with it in the ſame manner, as was Iuſt now directed for obſerving the Sun in the Horizon. In either of which ways there may be ſome Error, cauſed by

the

the Suns Refraction, which is inconſiderable, and therefore needs not to be taken notice of.

6.

By means of theſe Watches to find at Sea the Longitude of the Place, where you are.

Give to each of the Watches a name or a mark, as A, B, C; and before you ſet ſaile, ſet them to the time obſerv'd by the Sun in the place, where you are, and whence you are departing, allowing for the Æquation of the day, whereon you make your Obſervation; Which day you are to note, if the Watches be not well adjuſted; otherwiſe it is not neceſſary.

Then afterwards being at Sea, and deſiring to know the *Longitude* of the place where you are, that is, how many degrees the Meridian of that place is more *Eaſterly* or *Weſterly*, than the Meridian of that place where you did ſet the Watches; you muſt obſerve by the Sun or Stars, what time of the day it is, as preciſely as is poſſible, and note at the ſame time, to what hour, minutes and ſec. the Watches doe point (which time, if the Watches be not ſet to the right meaſure, is by the known daily difference to be adjuſted,) adding thereunto the Æquation of the preſent day, which gives you the time of the day, ſhew'd by the Sun, at the place where the Watches were ſet: And if this time of the day be the ſame with that obſerv'd where you are, then you are under the ſame Meridian with the place, where the Watches were ſet by the Sun; but if the time of the day, obſerv'd where you are, be greater than that ſhew'd by the Watches, you may be aſſur'd, that you are come under a more *Eaſterly* Meridian; and if leſs, you are come under a more *Weſterly*. And counting for every hour of difference of time, 15 degrees of Longitude, and for every minute, 15. minutes or ¼ of a degree, you ſhall then know, how many degrees, minutes, *&c.* the ſaid Meridians doe differ from one another.

E. g. Suppoſe, the Watches A. B. C. were ſet at the place, whence you parted, on the 20 of *February*, to the time of day obſerv'd by the Sun, abating the Æquation of the 20th of *Febr.* (viz 2 min. 28. ſec.) and ſuppoſe that the Watch A. be ſet to its right meaſure, but that B. goes every day 7 ſec. too ſlow, and C. every day 12. ſec. too faſt. Some days after, ſuppoſe the 5th of *May*, deſiring to know the Longitude of the place where you are at Sea, you obſerve the time of the day

h. — min. — ſec.

there to be —————————————— 5 — 18 — 10
And you find the Watch A. to point at —— 2 — 6 — 0
But the Watch B. to point at ———— 1 — 57 — 22
Going too ſlow by 7. ſec. every day, which makes in 74. days, (viz.
From the 20th of *Febr.* to the 5th of *May*) — 0 — 8 — 38
Which being added to its own time, gives the ſame

h. — min. — ſec.

with that of the Watch A, *viz.* ———— 2 — 6 — 0
You find alſo the Watch C to point at —— 2 — 20 — 48
Going 12 ſec. too faſt every day, which makes in 74. days ———————— 0 — 14 — 48
Which being ſubducted from its own time gives again ———————— 2 — 6 — 0
The time of day therefore by the Watches being -- 2 — 6 — 0
Adde thereunto the Æquation of the 5th of *May* - 0 — 19 — 29
And ſo you have for the time of day at the place where the Watches were ſet ———— 2 — 25 — 29
But the time obſerv'd being ———— 5 — 18 — 10
Exceeds this by ———————— 2 — 52 — 41
Wherefore the Meridian of the place, where you are May 5th, is more Eaſterly, than the places where the Watches were ſet, by ———— 2 — 52 — 41

deg. — m. — d.

Which being reduced to degrees, reckoning 15 deg. for an hour, comes to ———— 43 — 10 — 15

Tis true, that from the ſame reckoning it may be concluded, that you are 180. deg. more Eaſterly, which happens becauſe the Hour-*Index* goes round in the ſpace of 12. hours in the Watches; but the difference is ſo great, that one cannot be deceiv'd in it; elſe the Watch might be ſo made, that the *Index* ſhall goe round but once in 24 hours.

7.

To find the time of the Day at Sea.

Since that for finding the *Longitude*, the Time of the day at the place where you are muſt be known (as hath been ſaid above) you muſt have a care to obſerve that time as preciſely as is poſſible. For every minute of time, that you miſreckon, makes a 4th part of a degree in longitude, which amounts, near the Æquator, to above 15. Engliſh miles, but leſs elſewhere. Wherefore to find the time of the day with certainty, you are not to truſt to the Obſervation of the Suns greateſt Altitude, thence to conclude that 'tis juſt Noon, or that the Sun is in the South, unleſs, being betwixt the *Tropicks*, you have it juſt in the *Z*enith. For elſe the Sun being near the Meridian, remains for ſome time without any ſenſible alteration of its Altitude. Wherefore, though the Meridian Altitude may ſerve well enough for knowing the *Latitude* or the Hight of the Pole upon occaſion; yet it will not ſerve for finding preciſely the *Longitude* of that place. Much leſs are you to rely upon the Sea-*compaſſes*, thereby to find the preciſe time of Noon. Neither are the Aſtronomical Rings or other ſorts of Sundyals ſure enough for ſhewing the time to *minutes* and *ſeconds*. But it is better to obſerve the Suns Altitude, when 'tis in the *Eaſt* or *Weſt*, (the nearer, the better:) for being there, its Altitude changes in a ſhort time more ſenſibly than before or after; and thus from the *Hight of the Pole*, and the *Declination of the Sun* the Hour may be calculated; the manner whereof is ſufficiently taught by others; yet by reaſon that this Calculation is ſomewhat troubleſome, and that alſo there may be ſome Errors in the taking of the Suns Altitude, here follows an eaſier way.

8.

How by Obſerving the Riſing and Setting of the Sun, and the Time by the Watches, the Longitude at Sea may be found.

This way doth neither require the Knowledg of the *Hight of the Pole*, nor of the *Declination of the Sun*, nor the *Uſe* of any *Aſtronomical Inſtruments*: Neither can the Refractions of the Sun or Stars cauſe any conſiderable Error; the refraction of the Morning differing but little or nothing from that of the Evening of one and the ſame day, eſpecially at Sea. Thus then you are to proceed;

At the Riſing and Setting of the Sun, when it is half above the Horiſon, marke the time of the day, which the Watches then ſhew; and though you have in the mean time ſayl'd on, it is not conſiderable. Then reckon by the Watches, what time is elapſ'd between them, and add the half thereof to the time of the Riſing, and you ſhall have the time by the Watches, when the Sun was at South; to which is to be added the Æquation of the preſent day by the Table. And if this together makes 12. hours, then was the Ship at Noon under *the ſame* Meridian, where the Watches were ſet with the Sun. But if the ſumme be more than 12, then was ſhe at Noon under a *more Weſterly* Meridian; and if leſs, then under a *more Eaſterly*; and that by as many times 15. degrees, as that Summ exceeds or comes ſhort hours of 12: as the Calculation thereof hath been already deliver'd.

Suppoſe, e. g. that the Watches A and B, as before, were ſet with the Sun at the place whence you parted, the 20th of *Febr*; and the *Indexes* ſet to the Hour, min. and ſecond, ſhewed by the Sun, abating the Æquation of that day, *viz*. 2. min. and 20. ſeconds; the Watch A being reduc'd to the right meaſure, and B going too ſlow by 7 ſec. a day. Afterwards on the 22th of *May*, deſiring to know the Longitude of the place, to which you are come, you obſerve in the Morning the Sun

	h.	min.	ſec.
half above the Horizon when the Watch points at	2	30	10
And in the Evening, the Sun being half under the Horizon, when the ſame Watch points at	3	8	40
To find the Time elapſ'd between them, ſubducting the time of the Riſing	2	30	10
From	12	0	0
There remains	9	29	50
Adding thereunto the time of the Setting	3	8	40
You have for the time elapſ'd between the Obſervations	12	38	30
Whereof the half	6	19	15
Being added to the time of Riſing	2	30	10
You have the time by the Watch A, when the Sun was in the South	8	49	25

And after the ſame manner you are to ſeek the time by the
Watch B, when the Sun was in the South; which let be ——— 8---38---48
But this Watch going 7. ſec. a day too ſlow, it is retarded in
91. dayes, (from the 20th of Febr. to the 22. of May) 0---10---37
Which therefore added to the ſaid time gives- 8---49---25
That is the ſame time given by the Watch A. Now adding to
this time of the Watches, the Æquation of the 22th of May ——— 0---18---10
You have ——— 9--- 7---35
Which is the ſame time of the day with that of the place, where the Watches were ſet when the Sun was in the ſame Meridian with the Ship, or where the Ship was at Noon.

h. min. ſec.
The difference is ——— 2---52---25
Wherefore this laſt Meridian is by ſo much more Eaſterly, than the firſt; which being reduc'd to *degrees* (as hath been
deg. min. ſec.
formerly directed) make ——— 43.--- 6---15

'Tis manifeſt, that by this way you find preciſely enough the Longitude of the place, where you were at Noon, or the Time of the Suns being in the South: which, although it differs from the *Longitude* of the place, where you are when you obſerve the Setting of the Sun, yet you may eſtimate neer enough, how much you have advanc'd, or chang'd the Longitude in thoſe few hours, by the Log-line, or other Ordinary practiſes of reckoning the Ships way; or (which is the ſurer way) by the degrees paſs'd in 24. hours by a former days Obſervation.

You may alſo, inſtead of obſerving the Suns Riſing and Setting, obſerve the Setting firſt, and then next morning the Riſing; marking at both times the Time ſhow'd by the Watches; and find thence, after the ſame manner as before, the Longitude of the place where the Ship was at Midnight.

Finally, you may alſo, inſtead of the Riſing and Setting of the Sun, obſerve before and after Noon two equal Altitudes of the Sun, noting the time ſhown by the Watches, and reckoning in the ſame manner, as hath been ſaid of the Riſing and Setting: Yet it is to be conſider'd, that the Altitudes of the

Sun

Sun are beſt taken, when it is about *Eaſt* and *Weſt*, as hath been already intimated. But note, that in Sailing *North* and *South* you make not the Obſervations at the Suns riſing and ſetting, but at its being *due* Eaſt and Weſt.

9.

But you may, eſpecially in ſuch Quarters, as lye farr *North* or *South*, yea and wherever you will, put the Rule here preſcribed in practiſe, by taking 2. *equal* Altitudes of ſome known *Starr*, that riſeth high above the Horizon. For you ſhall thence, according to the mention'd Rule, know at what time by the Watches the Starr hath been in the South; and ſo the *Right Aſcenſion* of that *Starr* being known, as alſo the *Right Aſcenſion* of the *Sun*, you may thence eaſily calculate, what time it *then* was: Which being compar'd with the time of the Watches, as before, ſhall give the *Longitude* of the place where you were, when you had the Starr in the Meridian.

10.

If the Watches, that have gone exactly for a while, ſhould come to differ from one another (as in length of time it may well happen, that the one or the other faile a minute, more or leſs;) in that caſe it will be beſt to reckon by that, which goes faſteſt; unleſs you perceive an apparent cauſe, why it goes too faſt; ſeeing it is not ſo eaſie for theſe Pendulum-Watches to move faſter than at firſt, as it is to goe ſlower. For, the Wire, on which the *Pendulum* hangs, may perhaps by the violent agitation of the Ship come to ſtretch a little, but it cannot grow ſhorter; and the little Weight of the *Pendulum* perhaps ſlip downwards, but cannot get up higher.

11.

When you get ſight of any known Country, Iſland or Coaſt, be ſure to note the *Longitude* thereof as exactly as you can by the help of the Rules here preſcribed. *Firſt*, thereby to correct the *Sea-Maps*, after that the Longitude of a place ſhall have been found at divers times to be the ſame, ſo that you doubt no more of it. For all *Mapps* are very defective as to the Scituation of Places in reſpect of *Eaſt* and *Weſt*, chiefly where Seas are interpoſ'd. *Secondly*, to be able always to know in the proſecution of your Iourney, how farr you have ſail'd from any place to the *Eaſt* or *Weſt*. And if by any notable miſchance or careleſneſs all the Watches ſhould come to ſtand ſtill, yet you may at any place, whereof the ***Longitude*** is certainly known, ſet them a going again, and adjuſt them there by the Sun, and ſo reckon the ***Longitudes*** from that ſame Meridian. For, you are to know, that you are nor at all oblig'd to put *one certain* Meridian of any knowne place as a begining of the Longitude-reckoning; this hapening only in *Mapps*, or *Tables of Longitude*: As, when you take for that purpoſe the Meridian of the *Pico* in *Teneriffe*, or that of the Iſlands of *Corvo* and *Flores* (the moſt Weſterly of the *Azores*) or any others. Yet it were very fit, that all *Geographers* agreed and pitched upon one and the ſame *Firſt* Meridian, that ſo all places might be known by the ſame Degrees as well of *Longitude* as of *Latitude*; though in Voyaging it is ſufficient, to obſerve only the difference of Longitudes, beginning to reckon from the Meridian of any place, you pleaſe, as if it were the *firſt*.

12.

If it happen, that being at Sea all the Watches ſtopp, you muſt, as ſpeedily as is poſſible, ſet them a moving again, that you may know, how much you advance from that place towards the *Eaſt* or *Weſt*: Which is of no ſmall importance, ſince, for want of this knowledg, you are ſometimes by the force of *Currents* ſo carried away, that though you ſaile *before the Wind*, yet you are driven a *Stern*; of which there are many Exampl s.

The Method
Of a Iournal for the Watches.

The Watches being diſtinguiſht by marks as A, B, or the like, every day about Noon, or when moſt conveniently you can, obſerve the time of the day by the *Sun*, or by the *Starrs* at night, and ſubduct thence the *minuts* and *ſeconds*, that are adjoyn'd to that day in the *Table*, and write the remainder down in a paper, wherein 9. *Columns* or more are mark't, placing them in the *ſecond* column, having plac'd the *day* of the *Month* in the *firſt*. And at the ſame time write down the hours, minutes and ſeconds of each Watch in a diſtinct Column, all oppoſite

poſite one to another. Then in another Column write downe the *difference* between the time taken by Obſervation, and that given by the Watches or one of them. Then, one Column for the *Latitude*: one, for the *Longitude* by the Ordinary way of reckoning: another, for the Longitude taken from the difference between the *time* found *by Obſervation*, and that given by the *Watches*: and at laſt, a large Column to note the Accidents, that befall the Watches, *&c.*

An Extract of a Letter Written by Dr. Edward Brown *from* Vienna *in* Auſtria *March 3. 1669. concerning two* Parhelia's *or Mockſuns, lately ſeen in* Hungary.

I received the account of the *Parhelia's*, ſeen *Ianuar.* 30th laſt, ſt.n. about one of the clock in the afternoon, over the City of *Caſſovia* in *Hungary*. It was communicated to me from a Learn'd Ieſuit, call'd Father *Michel*, who lives at *Preſburg*, but is now in this City. There were two *Parhelia's*, one on each ſide of the true Sun, and they were ſo reſplendent, that the naked Eye could not bear the brightneſs thereof. One of them (the leſſer of the two) began to decay before the other, and then the other grew bigger, and continued well nigh two houres, projecting very long rays from it ſelf. They were both on that part, which was towards the Sun, tinged with a pale yellow, the other parts being ſomewhat fuſcous. There were at the ſame time ſeen ſeveral *Rainbows*, together with the Segment of a great white Circle, of a long duration, paſſing through the two *Parhelia's* and the Sun: and all this at a time, when the Air was almoſt free from Clouds, though here and there were ſcatter'd ſome very thin ones.

A Relation Of the Conferences held at Paris *in the Academy Royal for the improvement of the Arts of* Painting *and* Sculpture, *as 'tis found in the* Iournal des Scavans.

THeſe Conferences are held once in a Month by divers Able Maſters making reflexions and obſervations upon the rareſt pieces in the Cabinet of his Moſt Chriſtian Majeſty, the Eſta-

and Sciences, all that time, which they ſpend in acquiring the *Latin* Tongue.

Advertiſements,

1. *The Reader is deſired, to inſert in* Numb. 47. *p.* 951. *ſect.* 10. *after theſe words,* Why it goes too faſt, *this Note* (as it may happen, when by ſome accident the *Cheeks* retaine not their proper figures.) *And now if it ſhould be ſaid, that upon any foulneſs the Watch will goe faſter by reaſon of the ſhorter Vibrations of the Pendulum, it is to be conſidered, That this is only true when the Watches have* no Cheeks, *but when they have them* (*as in thoſe hitherto uſed*) *'tis not ſo.*

2. *If it ſhould be demanded, Why in the ſame* Tract *uſe hath not been made of* Tycho's *Æquation of Time, nor of that of* Bullialdus, *but one is given different from both? The Anſwer is, That the* Table, *there publiſht, is the Difference of the* Right Aſcenſion *of the Sun at Noon from the* Mean motion, *accounting from th 1ſt of* February; *which muſt be the* true *Æquation; unleſs the Velocity of the Earth*'s *Motion about her own* Axis *be not conſtantly the ſame.*

Errat.

Numb. 47. *p.* 945. *in the 2d columne blot out* diff. *before* 6. 5. 1. *and put it before the 3d rank of numbers above it, viz. before* 11. 49. 56.

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